# METHOD OF PRODUCING A DIFFRACTIVE STRUCTURE IN SECURITY DOCUMENTS

The present invention relates generally to a method of producing a security document or device, and in particular to security documents or devices which include an optically diffractive structure, or other visible or detectable effect such as a defraction grating or like device, or a polarisation pattern. The invention is applicable to the production of banknotes, and it will be convenient to hereinafter describe the invention in relation to that exemplary application. It is to be appreciated, however, that the invention is not to be limited to that application.

The practice of applying defraction gratings and like optically detectable diffractive and other structures to security documents and devices, such as credit cards, bank notes and cheques, has become widely adopted. Currently, defraction gratings and other structures are produced in multi-layer thin films supported on thin carrier structures. The structures are then transferred from the thin film carrier substrate to the security document or device, typically by using a hot-stamping process. Reflective optical defraction devices conventionally contain an ultra-thin vacuum metallised reflective layer, usually aluminium, adjacent to the diffractive structure within the multi-layer structure.

A number of disadvantages are associated with the production and application of optically diffractive and other devices in this manner. Firstly, the complex and highly specialised process required to produce the multi-layer optically diffractive device structure, which may contain at least four and frequently more layers, is costly. Secondly, an extra process step is required to transfer the optically diffractive device from the carrier substrate onto the security document or device. Thirdly, the resistance of the optically diffractive device as a whole to physical wear and tear and chemical attack is poor due to the weakness of the vacuum metallised reflective layer.

An aim of the present invention is to ameliorate or overcome one or more of the disadvantages of known methods for producing security documents or

devices including optically diffractive devices or other detectable effects such as polarisation patterns.

The present invention provides a method of producing a security document or device comprising a substrate and a detectable security device, the method comprising the step of:

exposing an area of the substrate on one surface to a photo-exposure process to generate a changed state in the surface of the substrate to produce a detectable effect in said surface, such as a polarisation pattern or an optically diffractive structure.

The present invention also provides a method of producing a security document or device comprising a substrate and a detectable security device, the method comprising the step of:

irradiating an area of the substrate on one surface with patterned laser radiation to ablate selected portions of the surface and thereby form an optically diffractive structure in said one surface.

In an alternative form, the invention provides a method of producing a security document or device comprising a substrate and a detectable security device, the method comprising the step of:

exposing an area of the substrate on one surface to a light source which causes photo-polymerisation of the substrate which in turn produces a polarisation state or pattern.

The present invention significantly simplifies the multi-layered structure of a security device when incorporated into the security document or device. The application of an optically diffractive or polarisation or like device may be easily integrated into the process of manufacture of the security document or device. Moreover, in those cases in which reflective optically diffractive or polarisation devices are used, it is possible to eliminate the use of a brittle metallised coating.

The method of producing a security document or device may further comprise the step of placing a mask in the path of the laser radiation to create said patterned laser radiation.

Conveniently, the substrate may be formed from a transparent plastics film. The transparent plastics film may be formed from polymeric material. The substrate may also be formed from paper, paper/polymer composites, coated paper and other non-transparent substrates in those cases where reflective diffraction devices were used.

In one embodiment, the substrate may further comprise a transparent coating applied to the transparent plastics film, the optically diffractive structure being formed in the transparent coating. The transparent coating may be formed from a polymeric material.

In one embodiment, the substrate may further comprise a reflective coating applied to the transparent coating. The reflective coating may be formed from polymeric material and may contain metallic pigment particles.

Conveniently, both the reflective coating and the transparent coating may be formed from material which is similarly resistant to physical degradation, such as by chemical attack.

In another embodiment, the substrate may further comprise a transparent layer applied to the transparent coating. The transparent layer may be formed from polymeric material. Conveniently, both the transparent layer and the transparent coating may be formed from material which is similarly resistant to physical degradation, for example by chemical means.

In a still further embodiment, this substrate may further comprise a reflective coating applied to the transparent plastics film, said optically diffractive structure being formed in the reflective coating. The reflective coating may be formed from polymeric material and may contain metallic pigment particles.

The substrate may further comprise a transparent coating applied to the reflective coating. The transparent coating may be formed from a polymeric material. The substrate may also be formed from paper, paper/polymer composites, coated paper and other non-transparent substrates in those cases where reflective diffractive structures are used. Both the reflective coating and

the transparent coating may be made of material which is similarly resistant to physical degradation, for example, by chemical means.

The method of producing a security document or device may further comprise the step of applying at least one opacifying layer to the substrate, said at least one opacifying layer only partly covering a surface of the substrate to leave at least said optically diffractive device uncovered by said opacifying layer.

The method of the invention is alternatively able to be used to create other types of security devices that do not use the phenomenon of diffraction as the basis for the visible optical pattern or effect that imparts security to the device and therefore to the documents that contain the device.

For example, it is possible to create an image in the substrate, or in the coating layers, of a security document that is only visible in polarised light.

In such a case, the image is not visible in normal un-polarised lighting conditions, and only becomes visible when viewed in certain polarised lighting conditions. The polarisation state of the lighting conditions under which the image may be viewed can be either linear or circular polarisation. It is further possible to create the means for checking the device (ie. by observing its visible presence) under polarised lighting conditions on the security document itself by providing the means for the polarised lighting conditions on the document itself. Such a device may be either a single multiple layer device. of which one of the layers may or may not be the substrate layer and the remaining layers would be coating layers applied in-line during the forming or printing process.

The following description refers in more detail to the various features of the method for producing a security document or device according to the present invention. To facilitate an understanding of the invention, reference is made in the description to the accompanying drawings where the invention is illustrated in a number of preferred embodiments. It is to be understood, however, that the invention is not limited to the preferred embodiments as illustrated in the drawings.

In the drawings:

Figure 1 is a schematic diagram illustrating steps involved in the method for producing a first embodiment of a security document including a reflective diffractive structure according to the present invention;

Figure 2 is a schematic diagram illustrating steps involved in the production of a second embodiment of a security document including a reflective diffractive structure according to the present invention;

Figure 3 is a schematic diagram illustrating steps involved in the production of a third embodiment of a security document including a reflective diffractive structure according to the present invention;

Figure 4 is a schematic diagram illustrating steps involved in the production of a first embodiment of a security document including a transmission diffractive structure according to the present invention;

Figure 5 is a schematic diagram illustrating steps involved in the production of a second embodiment of a security document including a transmission diffractive structure according to the present invention; and

Figure 6 is a schematic diagram illustrating steps involved in the production of a third embodiment of a security document including a transmission diffractive structure according to the present invention.

Referring now to Figure 1, there is shown a transparent plastics film 2 formed from polymeric material, used in the manufacture of polymer banknotes. The substrate 2 may be made from at least one biaxially oriented polymeric film. The substrate may comprise a single layer of film of polymeric material, or, alternatively, a laminate of two or more layers of transparent biaxially oriented polymeric film. The substrate 2 is seen in cross section in Figure 1. Whilst the invention will be described with reference to Figures 1 to 6 in relation to the production of polymer banknotes, it is to be appreciated that the invention may also be used in the production of credit cards, cheques and other security documents or devices, and that the function and properties of the substrate in those security documents or devices may vary.

In this example, a defraction grating or other optically diffractive device is formed on one surface 3 of the substrate 2 by eradiating an area of that

surface with pattern laser radiation. The patterning of the laser radiation incident on the one surface 3 of the substrate 2, may result from the placement of a mask in the path of the laser radiation. The mask 4 may have apertures 5 formed therein such that in those areas where the laser radiation passes through the mask, the light interacts with the surface layer of the substrate 2 in which the defraction grating is to be created, causing material to be ablated or otherwise removed to an appropriate depth in the surface layer of the substrate 2 and resulting in a three dimensional optically diffractive structure 6.

A reflective coating 7 is then applied to the oblated surface of the substrate 2. The reflective coating 7 may be a coated polymer layer, containing, for example, metallic pigment particles, or reflective particles, to perform a reflective function. The reflective layer 7 may be applied by conventional printing methods, and may fill the three dimensional structures formed by the laser oblation of the surface 3 of the substrate 2. The coated polymer layer 7 acts as a binding matrix to hold the reflective particles, and provides the strength and flexibility required for the reflective layer to resist physical wear and tear, while the pigment particles may be formed from a material which is resistant to chemical attack.

When incident light 8 from a light source 9 is reflected to a user 10 the reflected light 11 is observed as being diffracted.

Opacifying layers 12 and 13 may be applied to one or more opposing faces of the coated substrate. The opacifying layers 12 and 13 may comprise any one or more of a variety of opacifying inks which can be used in the printing of banknotes or other security documents. For example, the layers of opacifying ink may comprise pigmented coatings comprising a pigment, such as titanium dioxide, dispersed within a binder or carrier of heat activated cross linkable polymeric material. Alternatively, the coated substrate may be sandwiched between opacifying layers of paper.

In order to view the diffractive effect caused by the optically diffractive device, at least a first region of a surface of the substrate 2 may be left uncovered by the opacifying layers.

Figure 2 illustrates a first variation of the method for producing a security document or device according to the invention. In this figure, the substrate 2 is initially coated with a transparent coating 20. The transparent coating 20 may be formed from a polymeric material.

Laser radiation, patterned by a mask 4, is then used to ablate selected portions of transparent coating 20, and to form therein a three dimensional optically diffractive structure 21. A reflective coating, identical to the reflective coating 7 applied to the substrate 2 in Figure 1, is then applied by conventional printing methods to the transparent coating 20. Both the transparent coating 20 and the reflective coating 22 may be formed from coated polymer material or other like material which is similarly resistant to physical degradation, such as by chemical attack. In this way, a counterfeiter wishing to recover the optically diffractive device by desolving or chemically etching the reflective layer 22, would also cause the desolving or chemical etching of the transparent coating 20 and the optically diffractive structure formed therein.

Once again, opacifying coatings may be applied to one or both surfaces of the coated substrate structure 2, 20, 22.

A second variant of the method illustrated in Figure 1 is shown in Figure 3. In this figure, one surface of the substrate 2 is firstly coated with a reflective coating 25, identical to the reflective layer 7 in Figure 1. Laser radiation is then patterned by the mask 4 to ablate material from the reflective coating 25 to thus form a three dimensional optically diffractive structure 26 in the reflective coating 25.

Subsequently, a transparent coating 27 is applied to the reflective coating 25. The transparent coating 27 may fill the three dimensional structure formed in the reflective layer 25. Once again, the reflective coating 25 and the transparent coating 27 may be made from material which is similarly resistant to chemical attack or other physical degradation, in order to prevent the optically diffractive structure 26 from being recovered by a counterfeiter.

Whilst Figures 1 to 3 illustrate examples of a method of producing a security document including a reflective diffractive device, Figures 4 to 6

provide examples of a method of producing a security document including a transmission diffractive device. In Figure 4, one surface of the transparent polymeric film 2 is ablated by laser radiation passing through a mask 4, to form therein the same optically diffractive device 6 illustrated in Figure 1. However, in this example, no reflective layer is subsequently applied to the surface of the substrate 2, so that a defraction effect is observed by the user 10 when light 30 from the light source 9 is transmitted through the substrate 2.

As in previous examples, opacifying coatings 31 to 34 may be applied to opposing surfaces of the substrate 2, leaving uncovered regions or zones 35 and 36 to enable the light 30 transmitted through the optically diffractive structure formed in the substrate 2.

In a first variation of this method, as illustrated in Figure 5, an optically diffractive device 6 is once again ablated into a surface of the transparent substrate film 2. Subsequently, a clear coating layer 40 of different refractive index to the substrate film 2, is applied to the surface of the substrate 2. The transparent coating 40, as in previous examples, fills the three dimensional diffractive device 6, and prevents wearing of optically diffractive structure 6. The defraction effect produced by the structure 6 may once again be observed in light transmitted through the substrate and transparent coating.

In method 6, there is illustrated a second variation of the method for producing a security document including a transmission diffractive structure. In this figure, the transparent plastics substrate 2 is firstly coated with a clear coating 45 formed from a transparent polymeric material. A diffractive structure 46 is ablated into the clear coating 45 by means of incident patterned laser radiation. A transparent layer 47 is then coated onto the transparent coating 45 filling the diffractive structure 46 formed therein. The transparent layer 47 and the transparent coating 45 are formed from materials having different refractive indexes, in order that a defraction effect may be observed when light is transmitted through the security device. Where the method does not include transparent layer 47, the resulting document still functions as described above.

The device described in this example/embodiment of the invention relies on the ability to pattern the polarisation state of the material that constitutes one of the layers of the device. This applies to the layer which contains the viewable image and also in the case of the layer(s) which would act as the polarisation filters for creating the polarised lighting conditions under which the image of the device can be viewed. Specifically, a UV photo-polymerisable material is used in the layer(s) where the polarisation state is patterned. A polarisation state is created by aligning the molecular structure of the material, which is achieved by exposing the material to a UV light source such as a laser or a conventional UV lamp. The photo-exposure creates a molecular state with a specific polarisation state that is "fixed" by the photo-polymerisation process. The patterning of the polarisation states is achieved by masking the UV light source to create the different polarisation states spatially across the device.

Various specific configurations of the equipment required to do this are possible. For example the light source may be a UV laser or a conventional UV lamp. Similarly a single or multiple step masking process may be used to create the various polarisation states required in the different spatial regions on across the device.

In this embodiment of the invention, the appropriate layers are applied during the substrate opacification process. During this process, the layer(s) which require polarisation are exposed to the UV laser or other UV light source shortly after they have been applied in order to "fix" them into the appropriate polarisation state.

The process of creating the desired polarisation state in the substrate or coating is similar to the above described process of creating a diffractive structure with the exception that conventional UV lamps may replace the UV laser source referred to in that description.

It will be appreciated that the methods described in Figures 1 to 6 may be easily integrated into the normal multi-step process during which a substrate is coated or otherwise treated, to produce a security document or device, the laser process merely being integrated into this multi-step process. This method, and

the security document or device including an optically diffractive device produced by this method, eliminate the need for a separate manufacturing process to produce an optically diffractive device transfer foil and the separate hot stamp foil transfer process to transfer that diffractive device transfer foil to the product.

The method according to the present invention is capable of producing either reflective or transmissive optically diffractive devices, such as reflective optically variable devices or a transmission hologram.

Finally, it should be appreciated that modifications and/or alterations may be made to the method and security document or device without departing from the ambit of the present invention.